The study of the complex thread knurling process

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The study of the complex thread knurling process

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Abstract. The study carried out to research a manufacturing process of long products for mining industry by a method of cold knurling, in particular, on a stud of a self-drilling bolt used for strengthening of mountain rocks. The solution of the task was obtained by mathematical simulation of the knurling process in the FE software package that allows establishing stress-strain state parameters necessary to analyze forming and loading of the process. According to the R&D carried out on a basis of the two-rolled screw thread rolling machine was developed a technological process for which the knurling rollers were design and created. The manufactured pilot batch of items that's meeting the requirements for such type of anchors speaks of capability to maintain low-series production of self-drilling fasteners based on the complex profile cold knurling method of a long billet.

1. Introduction

Currently, the modern mining factories faced up with the problem of mine workings fastening in a rather unstable rocks. It's caused by increase in the depth of mining operations. In such circumstances, the mining factories are compelled to conduct boreholes with mine workings pre-fastening. In that case the emergency prevention is more important than ever. An important challenge for underground mines is prevention of rock bumps consequences too. Along with complex solution of the goals by achieving safety mine workings, also there is a question of the wider introduction of cost-effective support rock bolting, which allows to reduce metal consumption in 3-4 times in comparison with a heavy mining support, improve stability developments, increase mining working pace. It is reached by using new mine workings fastening technologies, applying of national production goods displacing import and cost reduction by intensification of support rock bolting production.

As part of the implementation of innovative Russian Federation projects in the field of mining there was a necessity to develop industrial designs of new import-substituting products based on UralEnergoResurs factory, which one of was the selfdrilling bolt. The selfdrilling bolt basically created for reinforcement of the extremely unstable rocks and soils by the injection strengthening method during drilling and blasting mining operations.

2. Object of study

The basic construction of the selfdrilling bolt is introduced in figure 1. The selfdrilling bolt is an anchor-type bolt that needed to mine workings pre-fastening and creating the effective support of

tunnel arch and walls by injection of micro cements, polymeric resins and acrylate gels in massif and concrete structures for the rockfalls prevention.

It represents the system consisting of drill bit, carrying steel hollow tube (anchor rod), coupling sleeve (anchor coupling), support plate and nut.

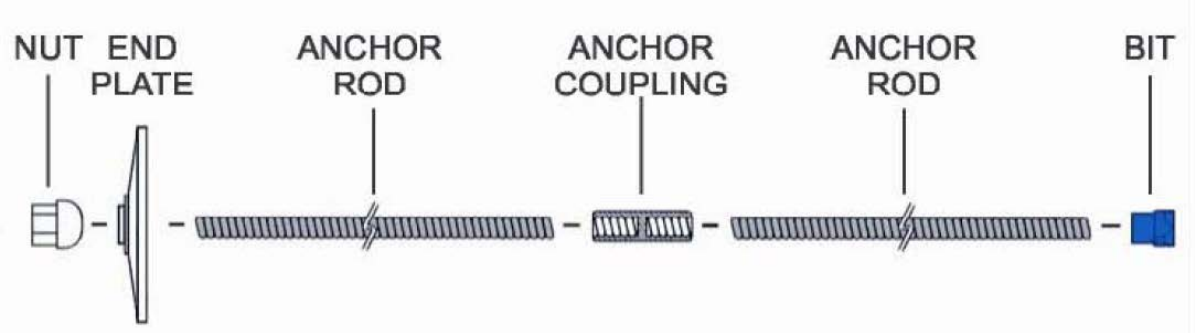


Figure 1. The basic construction of the selfdrilling bolt

The selfdrilling bolt is may use for vertical and horizontal mine workings fastening in the unstable rocks, rocks with irregular load capacity and high fracturing.

The drill bit allows using the selfdrilling bolt as a drilling tool in the machine drilling and drilling by human power. The coupling sleeve allows to extend the bolt multiple 2 meters and to make boreholes up to six meters depth by machine drilling. Also, the bolt can be installed in pre-drilled borehole.

Application of the selfdrilling bolt guarantees the uniform distribution of injection compositions and materials. The flowing out of waterproofing solutions outside are eliminated at the expense of rigging the selfdrilling bolt by a backpressure valve.

The length of carrying steel hollow tube is 2-6 meters. It has been proven that use the external round thread on the rod of the selfdrilling bolt [1-4] allows refining significantly adhesion of a puffed solution and the tube in comparison with smooth pipes and armature. The external round thread is also characterized by a major wear resistance [5, 6], increased of dynamic loads resistance due to lack of acute angles, simplicity of bolting and unbolting because of large circular helix angle of elevation.

The external round thread is usually gained by cutting or hot rolling [7, 8].

Some alternatives of the screw-shaped profile production are possible under the prevailing circumstances, there are:

- cutting by universal machine tool;
- cold knurling by profiled tool on a two-rollers rolling machine;
- hot thread rolling by thread-rolling tool on rolling mill.

The cost value and productivity analysis of new production variations has demonstrated that for the manufacturing by cutting too many machinery is required that'll cause serious capital investments and will have significant raise in the product costs. As for the hot thread rolling, the high rolling mill productivity compared to necessity of the products wouldn't allow full loading of the equipment what with a serious capital investment for adjusting the process will causes a financial failure.

The most useful manufacturing process from above-mentioned is cold knurling thread process by profiled tool on a two-rollers rolling machine.

However, there is a problem of evaluation the possibility of manufacturing this kind of product in such way with calculation of stress-strain parameters of the process to choose equipment parameters and design technological tools of the cold knurling process of a hollow billet in the two-rolled screw thread rolling machine. For this purpose, a modeling of the process using 3D FE software was carried out.

3. Modeling of cold knurling thread process by thread-rolling tool on a two-rollers knurling machine

The known knurling process includes operations of radial approach of one of the profiled rollers to the billet after which by friction forces a movement of the billet occurs along axis of the rollers combined with its own rotation across the billet axis. At the same time by compression of the rollers the profile on them leave reciprocal pattern on the billet surface. Containment of the billet in space is accomplishing by lower and upper (optional) knives of the screw thread rolling machine. The depth and the step of the thread are defined by setting the rollers distance between rollers axis and the initial profile of the knurling tools.

In order to minimize a number of objects inside the scheme of the cold knurling process [9] the process of rolling of the hollow billet by profiled rollers has been considered (figure 1). Therefore, the scheme includes a visco-plastic workpiece, and two rigid profiled rollers. The rear face of the workpiece fixed, profiler rollers are in a complex motion: (1) rotation around their own axis, (2) rotation around the axis of workpiece and (3) movement along the workpiece. Motion components of the profiled rollers are in agreement in a way that parallel coils of rollers don't crush neighbor coils of the knurled thread [10-12].

Figure 2 shows the thread profile in the result of the cold knurling process simulation. The geometry is in accordance with the roller's profile.

Results of measuring the stress-strain distribution in the deformation zone have been presented in figure 3. Values gained by the simulation speak of uneven distribution of state variables in the deformation zone (fig, 3, b). The entry coils of the tool are to be loaded mostly. At the same time constant values of stress show that remained coil do not only play part as guides for the workpiece but also are calibrating it. It should be noticed that metal flow intensity in the cross-section significantly decreases closely to departure of the workpiece from rollers (figure 3, c).

The stress-strain state data could be useful to evaluation of the tools and machinery loading in the knurling and also of possibility to produce this type of profile by cold deformation.

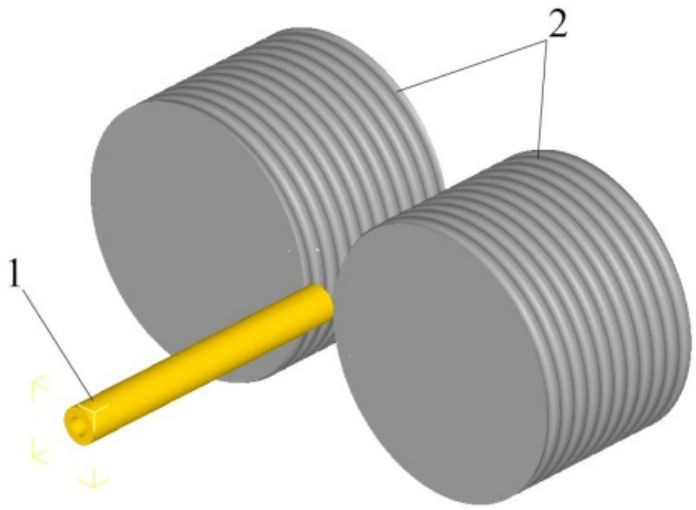
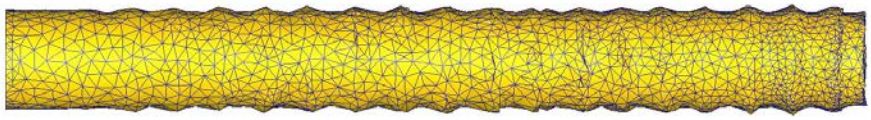
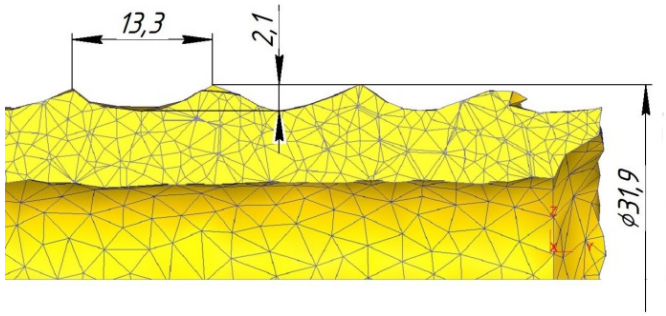


Figure 2. The scheme of the knurling process (1) the workpiece, (2) profiled rollers

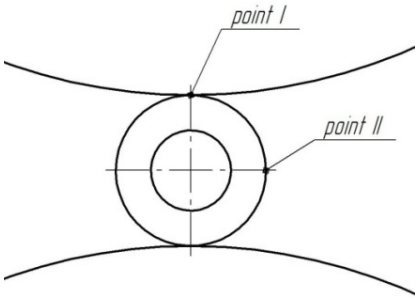


a



b

Figure 3. The knurled workpiece (a) final form, (б) the thread rolled profile



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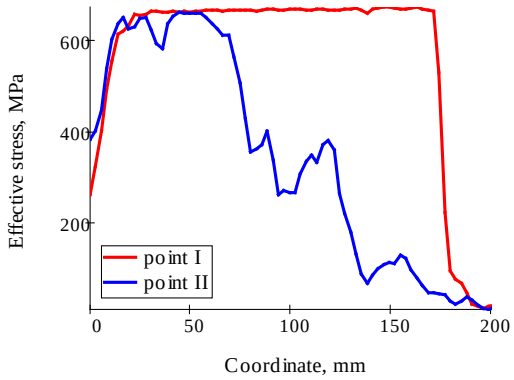

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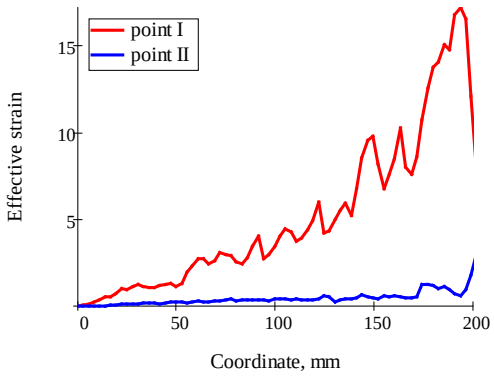

c

Figure 4. Results of stress-strain state measurements in the deformation zone (a) points of measurements, (b) effective stress, (c) effective strain.

4. Verification of the theoretical results

Based on the results of calculations, the technological process for the two-rolled screw thread rolling machine "GD-8" has been developed. The thread-rolling tool (Figure 5) and other accompanying technological equipment were designed and made. Fine-tuning of the rolling tool by "biting" of raw material has been generated.

After commissioning, the prototype production batch of anchor rods were manufactured in order to identify actual values of rolling force (250 kN) and production cycle (20min).

The prototype is checked for correspondence with technical requirements. As a demonstration, the sample of the rod with external round thread R32 on it, which was received by implemented production process, shown in Figure 7.

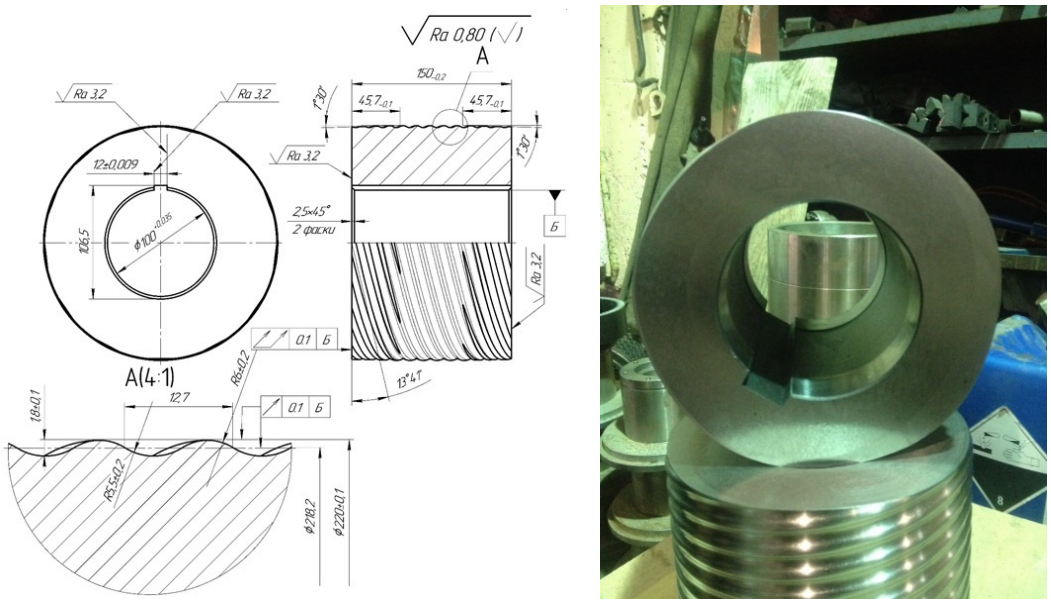

Figure 5. The construction of the thread-rolling tool R32

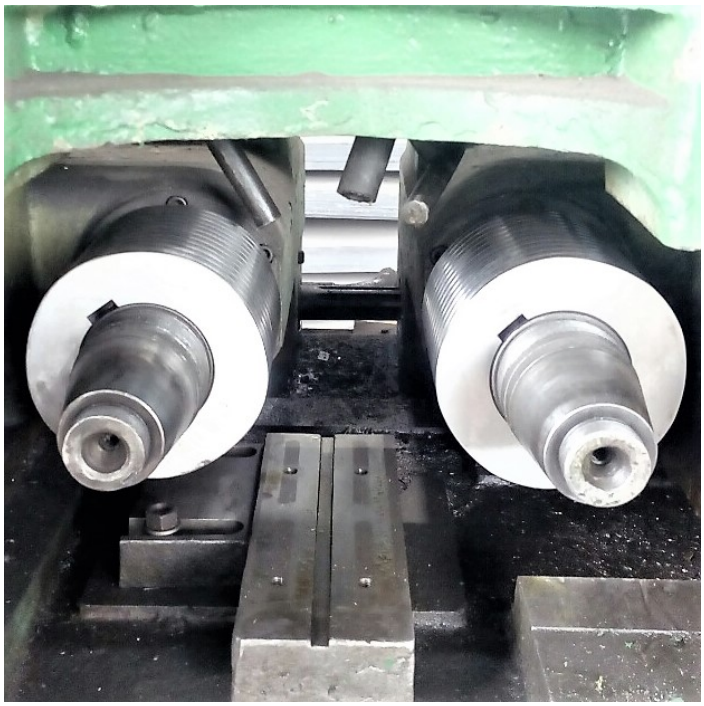

Figure 6. The set of the thread-rolling tool R32

Figure 7. An anchor rod with the external round thread R32

5. Conclusion

Following the study of cold knurling process by profiled tools on the two-rolled screw thread rolling machine to apply it as a production process for the mining goods, it may be concluded that the further implementation of the project will allow to organize small-scale production of The selfdrilling bolt which will be able to content the demand in high-quality, hi-tech and inexpensive support rock bolting for domestic consumers.

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